

REMARKS

Claims 1-15 are pending in the Application. Claims 16 and 17 are added with this Amendment. Support for newly added claims 16 and 17 is found in the Specification at page 7, lines 16-17. No new matter is added with this Amendment.

Applicants' invention is directed, inter alia, to a method of providing a seed layer substantially free of discontinuities by contacting a discontinuous seed layer with an alkaline copper electroplating bath comprising copper pyrophosphate. Sufficient current density is then applied to provide a metal seed layer substantially free of discontinuities. An advantage of the present invention is that the electroplating bath can be used to provide a seed layer substantially free of discontinuities and to fill the apertures with copper.

Claims 1, 2, 4, 6, 7, 9 and 11-13 have been rejected under 35 USC § 103(a) as being unpatentable over Cohen in view of Mahapatra. Applicants respectfully traverse.

The Official Action at page 3 states that Cohen, in referring to Figs. 3 and 4, discloses the "step of contacting a metal seed layer having discontinuities 126 disposed on a substrate 112 having one or more apertures having a size of $\leq 1 \mu\text{m}$ with a copper electroplating bath" Applicants respectfully disagree. Figs. 3 and 4 are described in Cohen starting at col. 6, line 63. The description of the seed layers in Figs. 3 and 4 is found in Cohen at col. 7, lines 52-67. Seed layer 126 is clearly referred to as "non-conformal" (see col. 7, line 52) and is obtained by PVD (col. 7, lines 53-54). Seed layer 128 is clearly referred to as "conformal" (col. 7, line 60) and is deposited by CVD or *electroless* technique (col. 7, lines 61-62).

In referring to Fig. 1, Cohen again refers to a conformal seed layer at col. 5, lines 18-21 as being deposited by CVD or *electroless* technique. Further, at col. 2, lines 21-25 and at col. 3, lines 38-39 Cohen only refers to CVD and *electroless* technique as providing conformal seed layers. Nowhere in Cohen is the use of an electroplating bath to provide a seed layer substantially free of discontinuities disclosed or suggested. The only discussion in Cohen regarding electroplating baths is concerned with the plating bath used to fill the features after the 2 seed layers are deposited. Thus, Applicants submit that Cohen neither teaches nor suggests the

use of a copper pyrophosphate electroplating bath to provide seed layers substantially free of discontinuities.

Mahapatra is relied upon for the teaching of the components of a copper pyrophosphate bath. However, Mahapatra does not fill the deficiencies of Cohen. The Mahapatra patent fails to disclose discontinuous seed layers, and, in fact, fails to recognize the problems associated with discontinuous metal seed layers. Such discontinuous metal seed layers are particularly problematic on substrates having one or more $\leq 1 \mu\text{m}$ apertures. This patent neither discloses nor suggests substrates having $\leq 1 \mu\text{m}$ sized apertures. In fact, Mahapatra fails to disclose or suggest substrates having apertures at all. Mahapatra fails to disclose or suggest integrated circuit devices.

There is nothing in Cohen or Mahapatra, either alone or in combination, that would lead one to combine these references. Even if one did combine them, one would at best first deposit a non-conformal PVD seed layer followed by a second conformal CVD or *electrolessly* deposited seed layer and then electroplate copper on the already continuous seed layer using the plating bath of Mahapatra. There is nothing in either reference alone or in combination that would lead one skilled in the art to use a copper pyrophosphate electroplating bath to provide seed layers that are substantially free of discontinuities. Applicants submit the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Claims 1, 2, 4, 6, 7, 9 and 11-15 have been rejected under 35 USC § 103(a) as being unpatentable over Tsai in view of Mahapatra. Applicants respectfully traverse.

The Official Action posits at page 4 that Tsai discloses a method including the step of contacting a metal seed layer 14 having discontinuities. Applicants respectfully disagree. Tsai merely discloses depositing a seed layer by PVD. This patent neither discloses nor suggests discontinuities in the seed layer. In fact, Tsai fails to recognize the problem of discontinuous seed layers at all. The Official Action further posits at page 4 that a PVD seed layer is inherently discontinuous, referencing Cohen. Again, Applicants respectfully disagree. Cohen, at col. 3, lines 34-37, is clear that PVD seed layers only fail to provide “continuous and complete step coverage” inside *very narrow openings with large aspect ratios*. Thus, a PVD seed layer in and of itself is not inherently discontinuous.

Tsai is directed to a method of preventing copper migration by filling features with a carbon-doped copper deposit. In order to achieve such carbon-doped copper deposit, the copper plating bath must have a certain carbon concentration. Only in this way can the purpose of Tsai, i.e. to prevent copper electromigration, be fulfilled. The only copper electroplating bath described is an acid bath (pH of 0 to 4). No other copper electroplating baths are taught or suggested by Tsai.

Thus, there is nothing in Tsai that teaches or suggests Applicants' claimed invention.

Mahapatra is discussed above. This patent does not fill the deficiencies of Tsai. Mahapatra fails to teach or suggest how to deposit carbon-doped copper deposit using a copper pyrophosphate bath.

There is nothing in either reference that would motivate one skilled in the art to combine these references and certainly not for the purpose of Applicants' claimed invention, i.e. to provide a seed layer substantially free of discontinuities. 1) Neither Tsai nor Mahapatra disclose or suggest seed layers having discontinuities. 2) Neither Tsai nor Mahapatra recognize the problem of discontinuous seed layers. 3) Tsai only discloses acid copper plating baths having a pH of 0 to 4. 4) Mahapatra only discloses alkaline copper pyrophosphate baths having a pH of 8.2-8.8. 5) Tsai only discloses acid copper plating baths requiring a certain carbon content to provide a carbon-doped copper deposit to prevent copper electromigration. 6) Mahapatra fails to disclose copper plating baths capable of depositing carbon-doped copper. In fact, the only copper plating bath disclosed in Mahapatra (col. 6, lines 20-35) is free of carbon-containing compounds. Thus, the bath of Mahapatra is incapable of depositing a carbon-doped copper layer.

Absent Applicants' own teaching in the Specification, there is nothing in either reference alone or in combination that would motivate one skilled in the art to combine these references. Applicants submit that the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Claims 3, 5, 8 and 10 have been rejected under 35 USC § 103(a) as being unpatentable over Cohen or Tsai in view of Mahapatra and further in view of Kaneko. Applicants respectfully traverse.

Cohen, Tsai and Mahpatra are discussed above alone and in combination. Kaneko fails to fill the deficiencies of Cohen or Tsai alone or in view of Mahapatra. The Kaneko patent discloses only a pyrophosphoric acid bath for the deposition of a copper-tin alloy. This patent fails to disclose or suggest discontinuous seed layers. In addition, this patent fails to recognize the need to repair such discontinuous seed layers. Kaneko is directed to lead-free solder plating (col. 2, lines 25-28). This patent fails to teach or suggest substrates having one or more apertures having a size of $\leq 1 \mu\text{m}$.

Absent Applicants' own teaching in the Specification, there is nothing in any of these references alone or in any combination that would motivate one skilled in the art to combine them. Even if one did combine these references, there is nothing in any of them either alone or in combination that teaches or suggests a method of providing metal seed layers substantially free of discontinuities by contacting metal seed layers having discontinuities with a copper pyrophosphate electroplating bath as claimed by Applicants. Accordingly, Applicants submit the Examiner has not made out a prima facie case of obviousness and respectfully request that this rejection be withdrawn.

Based on the foregoing, favorable reconsideration in the form of a notice of allowance is respectfully requested.

Respectfully submitted,



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